ENERGY CONVERSION DEVICES, INC.

QUARTERLY TECHNICAL STATUS REPORT

June 15 2004 - September 15 2004

Subcontract Title:	Development of Optically Enhanced Back Reflectors and Improved Deposition Processes for Amorphous Silicon-Based Photovoltaic Technologies
Subcontract Number:	ZDJ-2-30630-22
Technical Monitor:	Bolko von Roedern
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Program Goals

In this program, we plan to improve the module efficiencies through development of a new optically enhanced Al/ZnO back reflector and improved i-layer deposition process. In the case of the back reflector development, a multi-layered thin film structure consisting of films with contrasting indices of refraction placed between the Al and ZnO layers of the back reflector will be developed. These new types of back reflectors will be tested in amorphous silicon based single junction and multi-junction devices. The differences in n of the different layers of the multi-layered back reflector and electrical conduction through the multi-layered structure will be optimized to obtain the highest reflection values, highest currents and best cell performance. The ultimate goal is to achieve the high currents and cell efficiencies typically obtained with the Ag/ZnO back reflector with a new optically enhanced back reflector that can be used in the solar module products. For the multi-layered structure, focus will be on preparing the layers using sputtering techniques so that this technology might be quickly applied to ECD's present back reflector fabrication process that uses sputtering techniques.

In the case of the i-layer, the focus will be on preparing microcrystalline silicon based intrinsic layers for low cost, high stable efficiency solar cells through the use of microwave plasmas. In these studies, the effects of such deposition conditions as ion bombardment, substrate temperature and etchant gases on the grain size and film transparency will be studied and correlated with cell performance.

Achievement of the goals of this program and application of these advancements to ECD's joint venture company's production lines would lead to an immediate improvement in module efficiencies. These advances along with ECD's participation in the NREL a-Si teams with other development programs will contribute to the ultimate goal of achieving stable efficiencies of 15% using a low-cost, scalable, manufacturable techniques and inexpensive substrates.

This Quarter's Results

We are currently working on Al/Multi-layer (ML)/ZnO structure where ML is ZnO/ZnOSi/Si/ZnOSi where the ZnOSi is the low index of refraction layer and Si is the high index of refraction layer. In our last report, we showed the increased solar cell performance obtained when the a-Si deposition conditions for the back reflector were altered to achieve higher indices refraction near 3.4 to 3.5. During this reporting period, we focused on altering some of the deposition conditions for the low index ZnOSi layer to increase the solar cell efficiencies. In particular, the amount of oxygen added to the plasma was systematically varied. Table I displays cell results for a-SiGe:H cells made with Al/ML/ZnO back reflectors using different oxygen flows. The cells whose data is displayed in this table were made by depositing the Al at room temperature to achieve close to specular surfaces to remove any complications with textured surfaces. This IV data was taken using AM1.5 light filtered using a 630nm cuton filter to shine only red light on the devices, the only light to reach the back reflector in an a-Si/a-SiGe/a-SiGe cell structure. One can see that the cell short circuit current and efficiency improved with use of lower oxygen flow. We previously used the moderate flow as a standard recipe so this finding was an improvement to our back reflector performance.

Table I.
IV data for a-SiGe cells made with Al/ML/ZnO back reflectors.
IV data taken using 630nm filter.

Oxygen Flow	Voc (V)	Jsc (mA/cm^2)	FF	Rs (ohm cm)	Pmax (mW/cm^2)
High	0.569	6.32	0.577	18	2.07
Moderate (STD)	0.564	7.05	0.563	17.8	2.24
Low	0.562	7.54	0.560	15.0	2.37

In addition to the variation of deposition parameters, we also able to improve the back reflector performance by varying the back reflector layer thicknesses. While the layer thicknesses have yet to be fully optimized, the data in Table II shows the improvement in cell performance with the use of new layer thicknesses. Again these cells were made using specular surfaces (no texture). Increases in the cell current and efficiencies can be seen with the use of the new layer thicknesses.

Table I.
IV data for a-SiGe cells made with Al/ML/ZnO back reflectors.
IV data taken using 630nm filter.

Layer Thicknesses	Voc (V)	Jsc (mA/cm^2)	FF	Rs (ohm cm)	Pmax (mW/cm^2)
Old standard	0.562	7.54	0.560	15.0	2.37
New thicknesses	0.561	8.28	0.556	17.9	2.58

Figure 1 compares the quantum efficiency curves for the a-SiGe cells made prior to and after changes in oxygen flow during ZnOSi depositions and layer thicknesses. One can see a significant increase in the red portion of the spectrum consistent with the increases in J_{sc} measured using the 630nm filtered AM1.5 light shown in the tables.

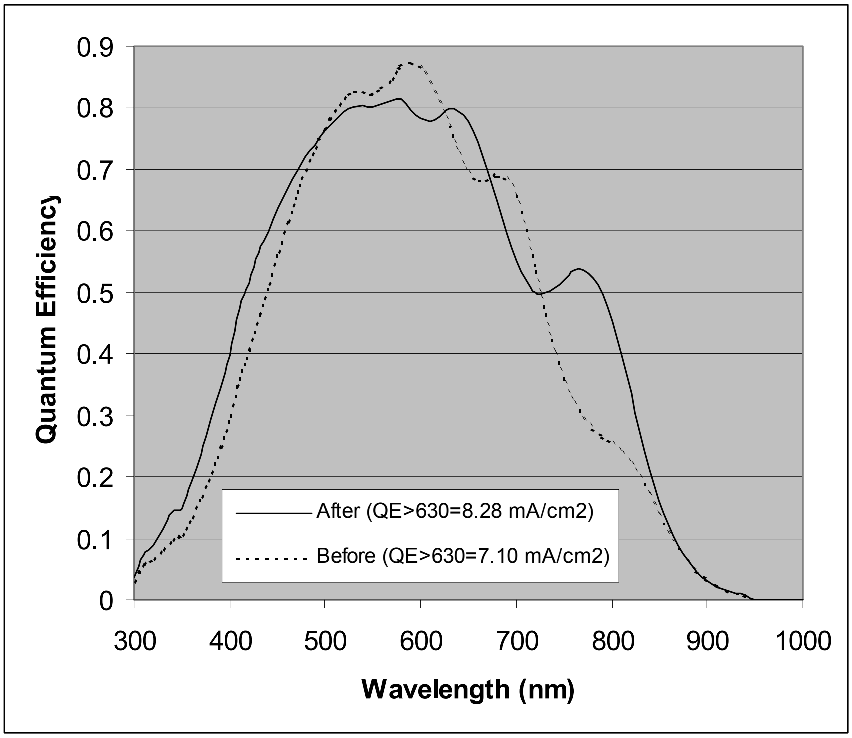

Figure 1. Quantum efficiency curves before and after ZnOSi layer and layer thickness improvements.

In the next reporting period, we will continue to optimize the back reflector layer thicknesses as well as begin to used textured back reflector surfaces to further increase the solar cell currents and efficiencies.